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PROJECT MYOPIA

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November 10, 1958

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**A PROPOSED HULL-MOUNTED PRO-SUBMARINE
TORPEDO COUNTERMEASURE**

[REDACTED]

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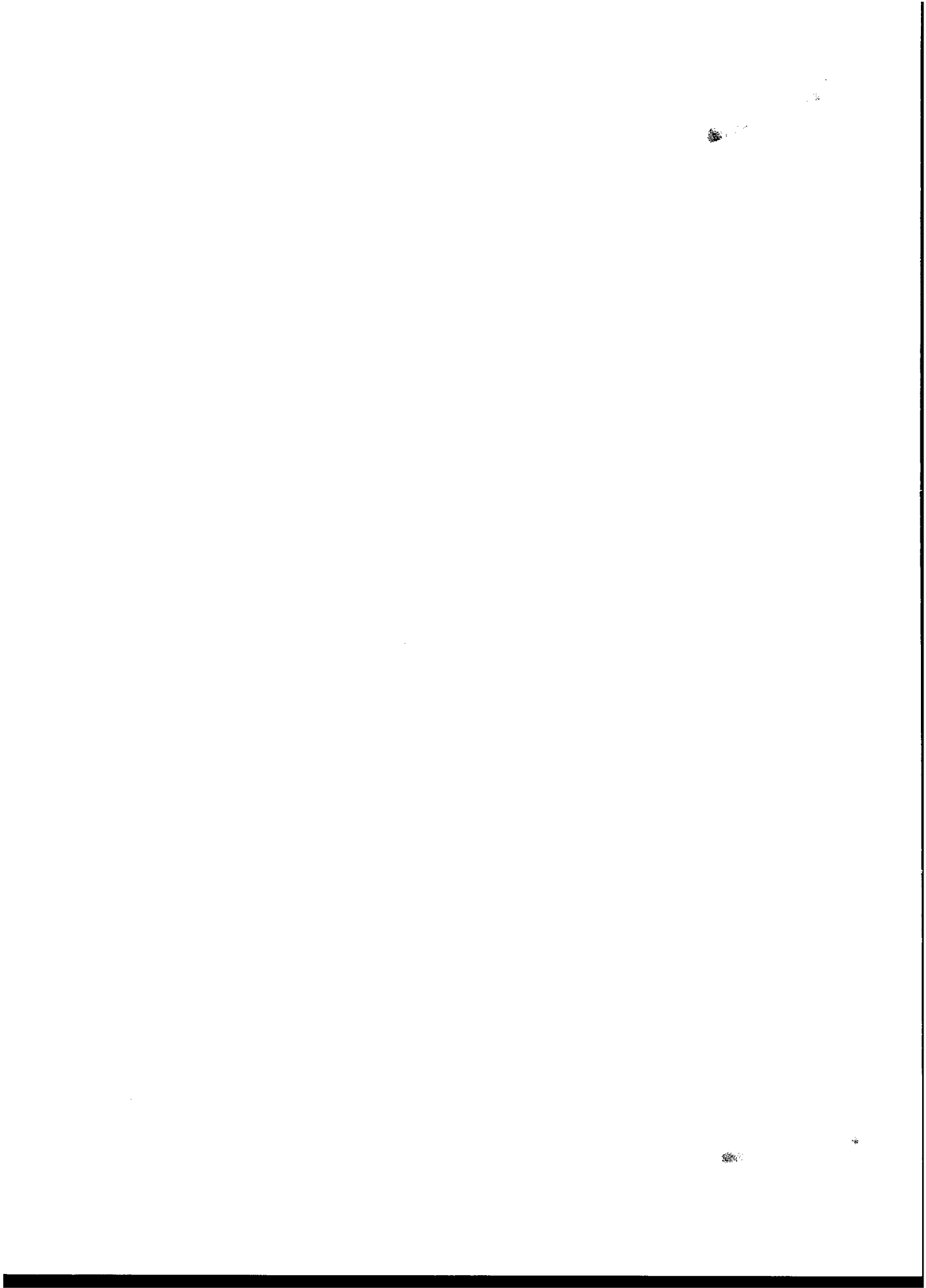
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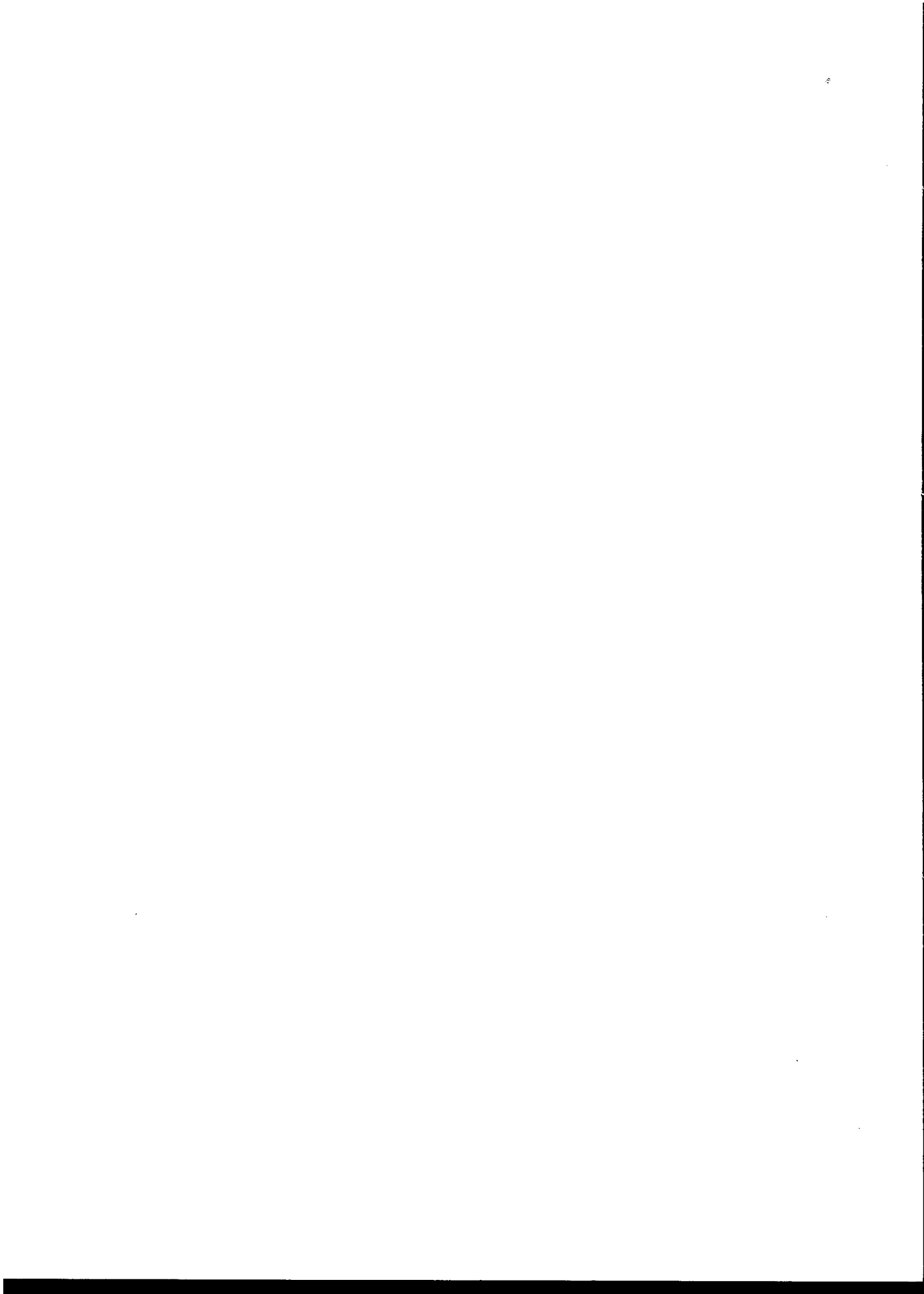


ABSTRACT

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A proposed hull-mounted pro-submarine torpedo countermeasure is examined, which is an adaptation of an NRL-developed countermeasure against tracking radar systems. This device should be effective against all known types of active acoustic homing torpedoes and, modified, possibly against passive acoustic torpedoes. Its operation is based on the fact that the apparent position of any finite target of complex structure, as seen by a tracking system, will wander about the physical center of the target. This natural phenomenon is exploited by the countermeasure device so that the echo returned to the tracking system appears to come from a location many target spans away from the target. Preliminary experimental data indicate the feasibility of this technique as applied to sonar.

Manuscript submitted September 29, 1958



PROJECT MYOPIA
A PROPOSED HULL-MOUNTED PRO-SUBMARINE
TORPEDO COUNTERMEASURE
[REDACTED]

INTRODUCTION

A radar countermeasures device (Project Cross-Eye) has been developed at NRL which is able either to cause a tracking radar system to break lock and return to an acquisition phase or to cause confusion in a tracking radar system which would render the system ineffective (1). This device operates over a broad frequency band and is simultaneously effective against an unlimited number of tracking radars. Because attacking sonars have characteristics similar to those of tracking radars, this technique has application in the field of sonar as a pro-submarine countermeasure against active acoustic homing torpedoes. There is also the possibility that a modification of this technique could be used against passive acoustic homing torpedoes.

Fundamentally the system operation would be as shown in Fig. 1. A set of 2 to 6 echo repeaters on the submarine would sample the sonar pulse of the torpedo and send back an echo which creates an increased noise condition as well as an apparent source remote from the submarine, thus causing erroneous target bearing and depth information to be accepted by the homing system.

THE CROSS-EYE TECHNIQUE

The Cross-Eye system is a countermeasure to any type of target-locating device which uses a directive receiving element to determine the bearing of a target by measuring the angle of arrival of a wave propagated from the target. This countermeasure technique produces a large source of echo signal that appears to the target-locating device to come from a location many target spans away from the target. The size of the echo and the apparent location of the target are both readily controllable.

The Cross-Eye system is based upon a natural phenomenon, observed with any finite size target of complex structure, called target angle noise or target glint which has been studied extensively in the field of radar (2,3). Target angle noise is a wander of the apparent position of a target, as seen by a tracking system, about the physical center of the target and is a function of the relative phase and amplitudes of the echo signals from the individual reflecting elements of the target. The wander is a function of any motion of the target which changes the relative distances of the reflecting elements of the target and, consequently, the relative phases of the echo signals from these elements as seen by the tracking device.

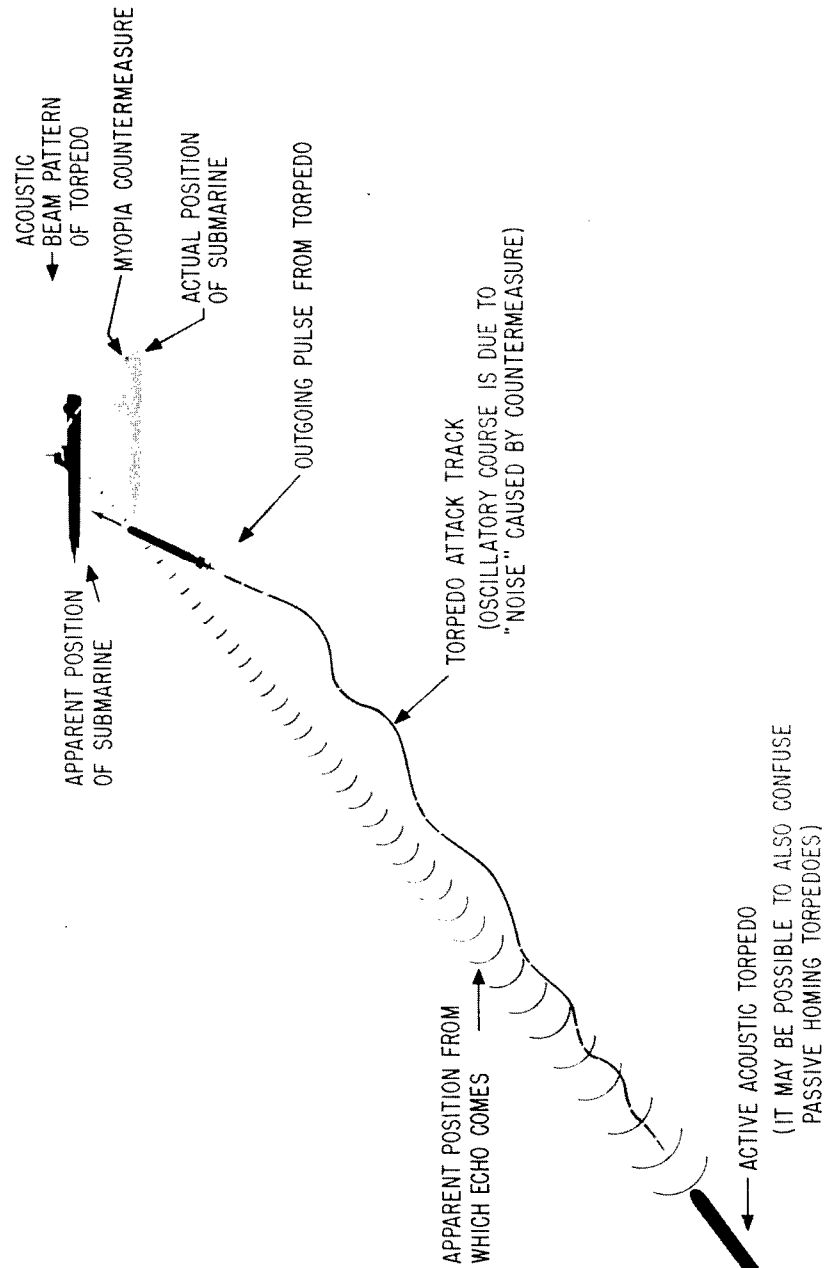


Fig. 1 - Proposed Project Myopia submarine countermeasure against acoustic homing torpedoes [REDACTED]

An interesting aspect of target angle noise is that it has peaks which fall beyond the physical extent of the target. This phenomenon is readily demonstrated by a target composed of only two reflecting elements: The error caused by a two-reflector target with respect to the midpoint of the target was shown (1,2,4) both theoretically and experimentally to be

$$E = \frac{L}{2} \frac{1 - a^2}{1 + a^2 + 2a \cos(\phi_1 - \phi_2)} \quad (1)$$

where:

L = spacing between the two reflectors

a = relative amplitude of the reflector echoes

$\phi_1 - \phi_2$ = phase difference of the reflector echoes as seen at the target.

This function is plotted in Fig. 2 to show the large errors which may be introduced into a tracking system.

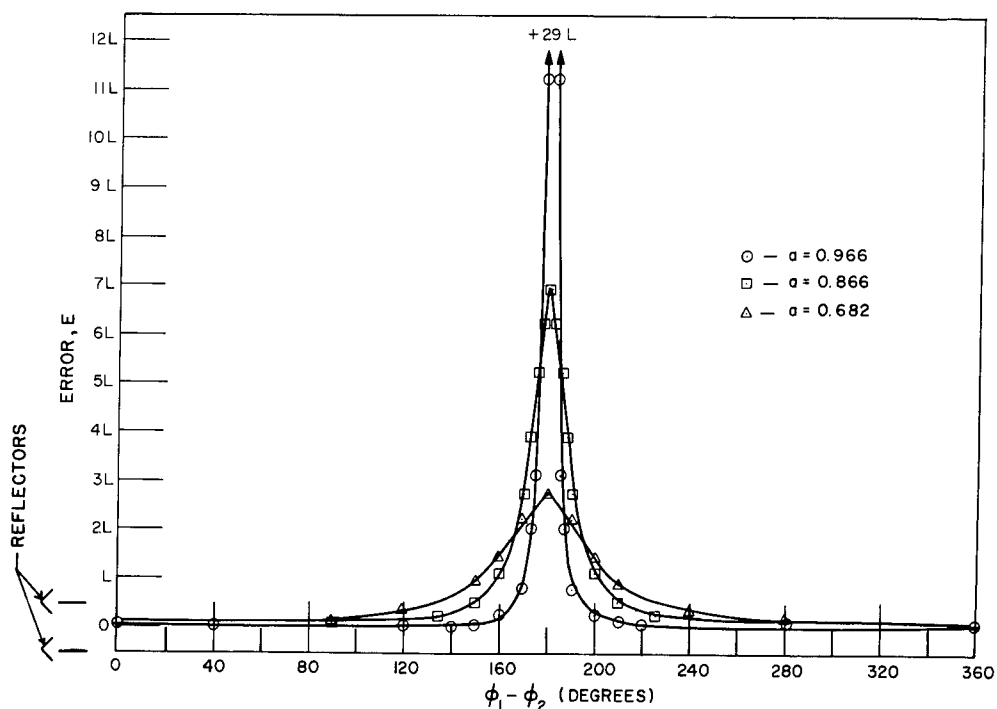


Fig. 2 - Theoretical tracking point on a two-reflector target [Unclassified]

The purpose of the Cross-Eye countermeasure is to take advantage of the target angle noise phenomenon by providing two large echo sources at the target and adjusting the relative phase as seen by the radar so that the echo sources appear to be many target spans away from the target. The difficulty in using the two-reflector phenomenon is to maintain the 180-degree relative phase as seen by the radar, because it is dependent upon the exact bearing of the radar with respect to the target. The Cross-Eye technique (1) utilizes two crossing paths, as shown in Fig. 3, whereby the signals re-transmitted to the radar are received at locations opposite from the point where they are re-transmitted. Thereby, two equal triangular paths are provided such that, regardless of the radar location, the two signals travel identical paths. In the Cross-Eye system the signals are amplified and caused to have a 180-degree relative phase before re-transmission to provide maximum error at the target.

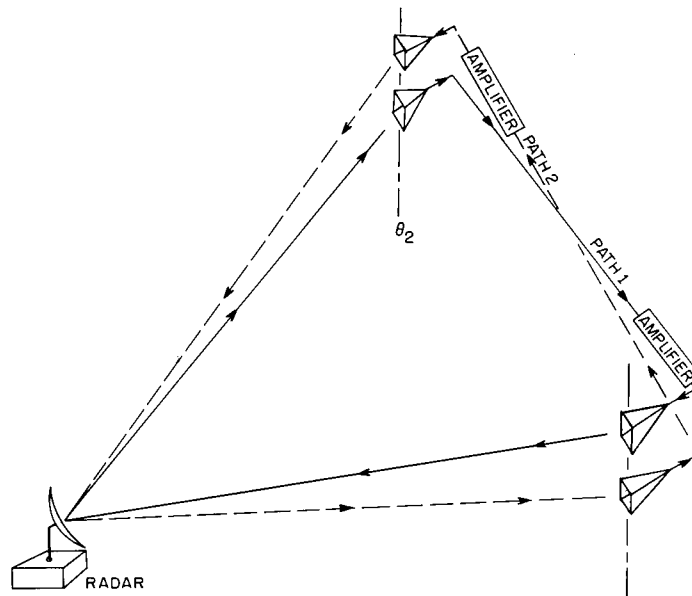


Fig. 3 - Reciprocal triangular paths provided by the Cross-Eye system [REDACTED]

APPLICATION OF CROSS-EYE TO SONAR

The application of the Cross-Eye countermeasure to sonar (Project Myopia) is feasible because of the parallels which exist between sonar and radar. First of all, both sonar and radar use similar wavelengths and similar techniques for search and tracking. In addition, target angle noise is a common problem to both radar (glint) and sonar (target wander). The most direct indication of the

compatibility of the Cross-Eye technique to radar and sonar, however, is the fact that the problem associated with the two-reflector phenomenon—the basis of the countermeasure—is common to both. This is the low-angle effect where a target and its image reflected from a surface are unresolved. The result is the error, described in Eq. (1), for two reflectors having peak excursions which greatly exceed the separation of target and image.

In order to confirm the expected applicability of the Cross-Eye technique to sonar, a preliminary experiment was run. Two transmitters were set up approximately 4 inches apart with a directional sonar receiver 12 feet distant. The frequency used was 37 kc. First each transmitter was turned on separately; then both together, in phase; then both together, 175 to 180 degrees out of phase. (The phase relation was related to the position of the receiver.) The beam pattern (Fig. 4) shows that in the out-of-phase condition (as would be used in the countermeasure), the maximum amplitude occurs outside the geometry of the two transmitters. Two amplitude peaks were observed because of the short range of the experiment; however, at normal operating range only one displaced peak would occur, falling outside the target area.

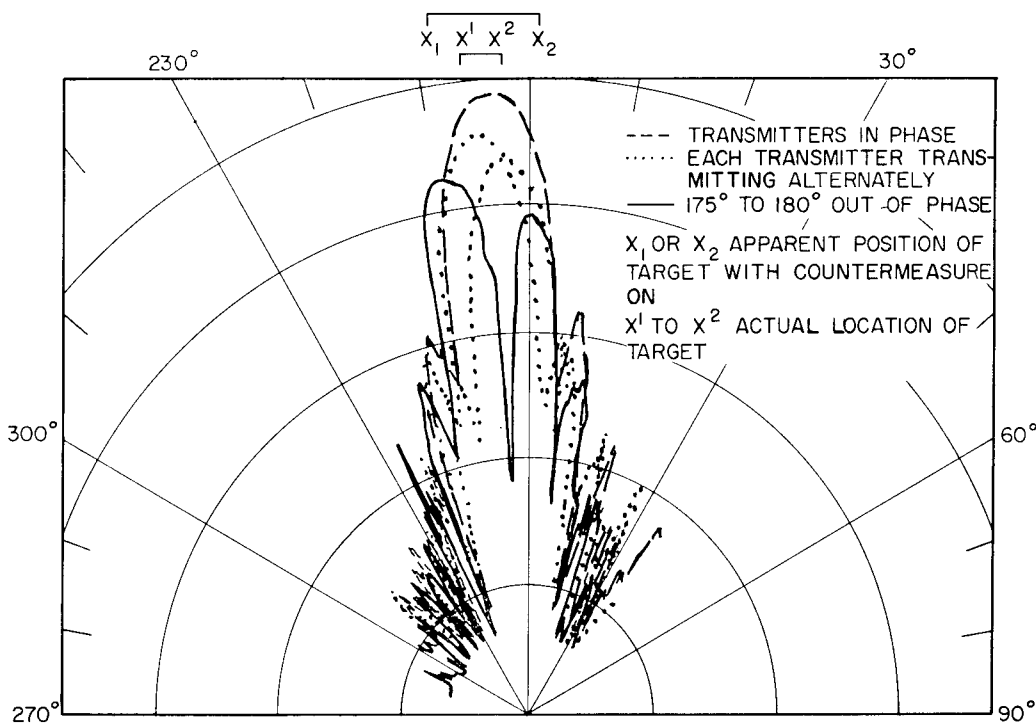


Fig. 4 - Sonar beam patterns showing target bearing distortion caused by the Cross-Eye technique [REDACTED]

A second experiment was then run in which two transmitters were positioned between 2 and 40 feet apart and a split-beam receiving transducer was located at various ranges between 300 and 1000 yards away. This test was performed in the Chesapeake Bay in water depths between 25 and 50 feet. The frequency used was 14 kc. The phase between the two transmitters was shifted using a hand-rotated phase shifter and a sector-scan indicator connected to the receiver plotted phase difference between the two receiver halves (horizontal) against time (vertical). The results are shown in Fig. 5 for a 500-yard range; the slash lines are the positions where the two transmitters are approximately out of phase (In the proposed equipment this condition would occur the majority of the time.) It is seen that the shift in apparent bearing is as much as 20 degrees from the true position of the transmitters.

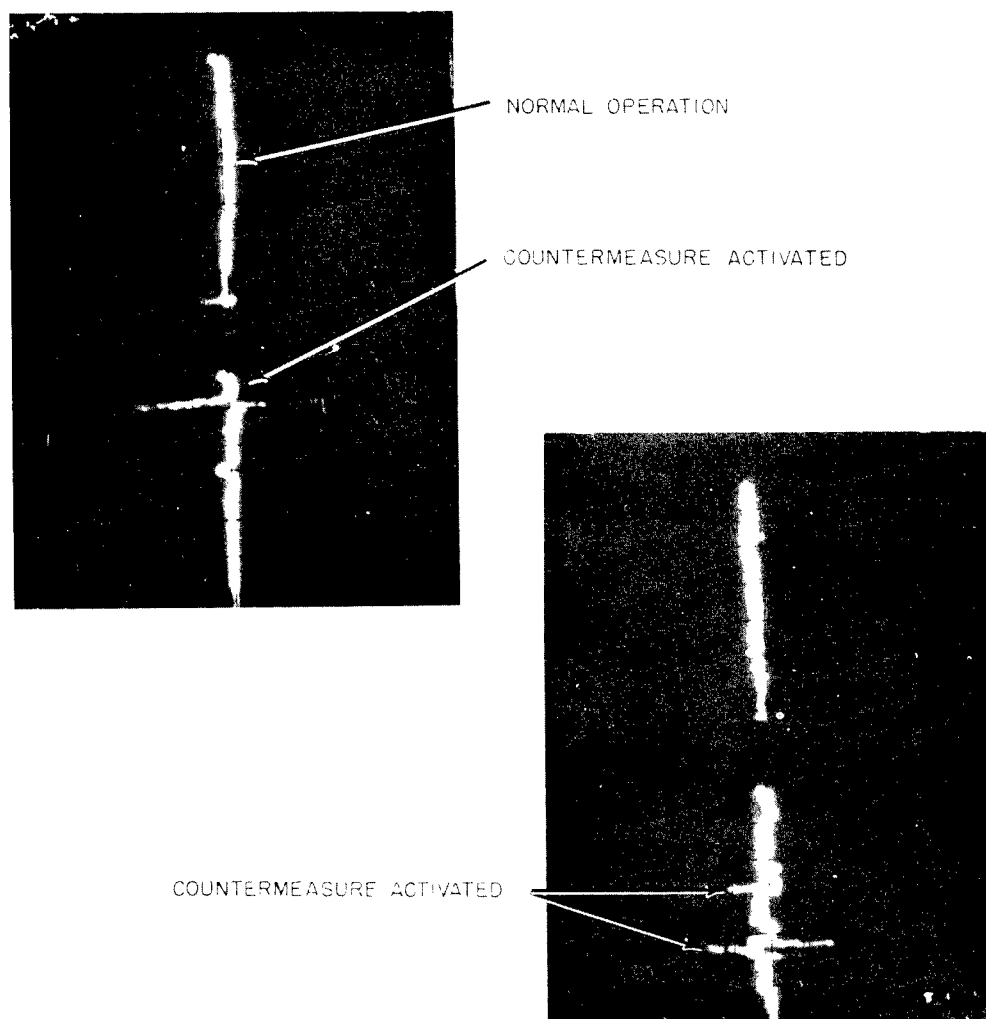


Fig. 5 - SSI display showing shift in apparent bearing of two-point target at 500-yard range [REDACTED]

TACTICAL EMPLOYMENT

Tactically this system could operate as follows against active acoustic torpedoes:

1. The sonar operator, upon hearing an active acoustic torpedo searching in the area, would estimate the range and inform the submarine commander.
2. If the range were relatively short, say 150 yards or less, the submarine commander would order the countermeasure activated.* If the range were greater than this, the system would remain deactivated until the sonar operator observed that the torpedo had shifted from a search to an attack phase. This change is noticeable because, as the torpedo leaves its spiral search pattern to home on the target, the intensity of its pulse is received at a more constant amplitude.
3. If, then, the torpedo acquired the target and made an attack run, the countermeasure would deflect the torpedo in both bearing and depth and so cause it to miss. A re-attack or multiple attacks would also be deflected.

A variation of this technique would be to have the countermeasure activate automatically. This, however, would require field tests to indicate its effectiveness. Another variation, that of using the countermeasure against passive acoustic torpedoes, should be feasible but would require more research data than defense against active acoustic torpedoes.

CONCLUSIONS

A hull-borne pro-submarine torpedo countermeasure proposed for defense against active acoustic homing torpedoes has been examined. This countermeasure system could have the following advantages:

1. It can be turned off or on, almost instantaneously, at the discretion of the submarine commander.
2. It need not be activated until the torpedo appeared to be homing on the submarine.
3. It would be effective against a multiple-torpedo attack or against multiple attacks by one torpedo.
4. The torpedo cannot bypass this system as it can decoys.
5. It can be used in conjunction with presently existing decoy techniques.

* If the searching torpedo were at a range less than 150 yards, the probability of its locating the submarine is already quite high and activating the countermeasure would not effectively increase this probability. However, if the range were greater than 150 yards, not activating the countermeasure would prevent drawing the torpedo into the near vicinity of the submarine, should it fail to acquire the target.

6. It is a countermeasure relatively unaffected by existing counter-countermeasures. It is suggested that a counter-countermeasure for torpedoes be explored.

7. It should have more value as a final than as an interim system. It is believed that as submarine speeds, and consequently torpedo speeds, increase the effectiveness of the device will also increase. The reason for this is inherent in the dynamics of high-speed vs low-speed systems and their attendant control systems.

8. It is based on an experimentally demonstrated phenomenon. The basic research for this system has already been performed by the Radar Tracking Branch of NRL so that the cost of the research and development that would be necessary to modify this system for sonar use should be small compared with its possible advantages.

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